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(54) Title:  PROCESS FOR DETECTION OF PARTICULAR QUALITY PROPERTIES IN INDIVIDUAL ARTICLES OF FOOD

(57) Abstract

Boar taint in individual carcases of uncastrated boars or parts thereof is determined in a fast and simple manner by determining IR-spectrophotometrical transmission data for the individual carcase or part or preferably on a sample from the carcase or part, and comparing the spectral data registered with corresponding data having a statistical relationship to boar taint. A suitable determination is determination of the ratio between the absorptions at two different wave lengths in the range of 1275 - 1325 $cm^{-1}$ in the IR spectrum of the fat sample. A still higher correlation between the particular spectral data and the organoleptic data is obtained when one or more further parameters with statistical correlation to the odour image is/are included, e.g., the concentration of unsaturated fatty acids in the fat of the boar carcase.

## PROCESS FOR DETECTION OF PARTICULAR QUALITY PROPERTIES IN INDIVIDUAL ARTICLES OF FOOD.

The present invention relates to a process for detection of particular quality properties in individual articles of food or raw articles for foodstuffs, i.e. "boar odour and boar taste" ("boar taint") in carcases of non-castrated boars or parts of such carcases, which detection may be incorporated as a natural stage in the production process of treating the carcases with a view to achieving a sufficiently reliable criterion for assessing in which category of two or more organoleptic quality categories the individual carcase or part is to be sorted.

Boar odour and boar taste, called "boar taint" below, are, such as the name suggests, a characteristic of boars which in contradistinction to their sisters (sows) and castrated brothers (hogs) have a characteristic sweat-like or urine-like smell in the meat. As a certain part of the consumers are sensitive towards this smell, all small boars are castrated in Denmark and in most other countries. However, this procedure involves a considerable loss in production as growth and meat quality are considerably lower for castrates than for boars.

However, the point is that only about 5 per cent of the boars of normal slaughter weight smell so heavily that it will be inconvenient, and for the reasons stated below it would be desirable if castration could be avoided and those animals which show considerable boar taint could instead be sorted out and used for products in which the taint is concealed.

Until now there has, however, not been any method available through which carcases showing boar taint could be sorted out in a slaughtering line in a sufficiently efficient way.

There are methods for the detection of what is believed to be the main component of the boar taint, i.e. androstenone, but those methods which until now have been tried cannot be considered for an on-line detection in slaughterhouses. The known methods are high

pressure liquid chromatography, gas chromatography-mass spectro-
metry, radioimmunoassay, enzyme-coupled immunosorbent assay and
gas-liquid chromatography. All of these methods are complicated,
labour-intensive and slow, and they require apparatus which can
5　　hardly be used in slaughterhouse environment in continuous opera-
tion.

To give an understanding of the problems in connection with the
present example of an organoleptic property, that is, boar taint,
10　　boar taint will be discussed in greater detail below:

Boar taint was investigated for the first time by Lerche in 1936
(Geschlechtsgeruch bei Eberkastraten, Z. Fleisch- u. Milchhyg.
46, 417, (1936)). Thereafter, there were only scarce activities in
15　　the field until 1968, when the appearance of the mass spectrometer
enabled R.L.S. Patterson (5α-Androst-16-ene-3-one Compound Re-
sponsible for Taint in Boar Fat, J.Sci.Fd.Agric., 19, 31 - 38,
(1968)) to identify what he believed was the main component in boar
taint and which is still considered the main component in boar taint,
20　　i.e. androstenone (5α-androst-16-ene-3-one). In a later article (Iden-
tification of 3α-Hydroxy-5α-androst-16-ene as the Mush Odour Com-
pound of Boar Submaxilliary Salivary Gland and its Relationship to
the Sex Odour Taint in Pork Meat, J.Sci.Fd.Agric., 19, 434 - 438,
(1968)), Patterson describes the indentification of the related com-
25　　pound 3α-hydroxy-5α-androst-16-ene from boar salivary glands and
presents the hypothesis that this is the primary olfactory communi-
cation compound (sex pheromon) and that surplus thereof is stored
in the fat tissue in oxidised form as androstenone. The deposit va-
ries considerably; thus, Øystein Andresen (Øystein Andresen &
30　　Håvard Bakke, 5α-Androstenone in Fat from Boars Selected for Rate
of Gain and Thickness of Back Fat and from Boars Used in Artificial
Insemination Service, Acta. Vet. Scand., 16, 492, (1975)) has
found a variation from 0.8 to 7 μg/g from the shoulder region to
the loin region.
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The fact that androstenone is considered to be the main component
in boar taint is related to the fact that this compound has a smell
which resembles boar taint to a high degree, and that, until now,

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this is the compound which has been found to have the highest
(although not very high) correlation to organoleptic assessments.

That other facts than the androstenone concentration are related to
the boar taint appears, for example, from the fact that odour panel
investigations on pure androstenone (N.M. Griffith & R.L.S. Patter-
son, Human Olfactory Response to 5α-Androst-16-ene-3-one Princi-
pal Component of Boar Taint, J.Sci.Fd.Agric., 21, 4 - 6, (1970))
do not give the same result as on on boar meat. Also, several works
have been described which show that other circumstances contribute
to the odour image. Thus, J. Wismer-Pedersen (Produktion og
smag af ornekød, Konserves & Dybfrost, 4, 38, (1969), and Land-
økonomisk Forsøgslaboratorium, Efterårsmøde, p136, (1968)) has
demonstrated a positive correlation to the fatty acid composition
(the degree of unsaturation) and to the hexanal concentration. The
influence of the fatty acid composition has also been investigated
in Lund (B. Malmfors, K. Lundström, I. Hansson, Interrelations
between 5α-Androstenone, Boar Taint, and Fatty Acid Composition,
In. Prep. Dept. of Animal Breeding, Agr. Coll. Uppsala). Vold
(E. Vold, Fleischproduktionseigenschaften bei Ebern und Kastraten,
Meldinger fra Norges Landbrukshöjskole, No. 16, 49, (1970)) has
identified a further component which manifests itself in the boar
taint odour immage, that is, skatol, 3-methylindol. Finally, the
above-mentioned sex pheromon, androstenol, also occurs in the fat
tissue (K.W. Berry & J.D. Sink, Isolation and Identification of 3α-
hydroxy-5α-androst-16-ene and 5α-androst-16-ene-3-one from Por-
cine Adipose Tissue, J. Endocr., 51, 223 - 224, (1971)), and al-
though it has a pleasant musk-like odour, it must also contribute
to the total odour image (R.H. Thompson, A.M. Pearson, K.A.
Banks, Identification of some $C_{19}$-$\Delta^{10}$ Steroids, J. Agr. Food Chem.,
20, p185, (1972)). Furthermore, a great number of related hormones
from boar testicles have been identified (O.B. Gower, 16-Unsaturated
$C_{19}$ Steroids. A Review of their Chemistry, Biochemistry, and Pos-
sible Physiological Role, J. Steroid Biochemistry, 3, 45, (1972));
in addition to androstenone and androstenol, these are androstenan,
androstenandiene, androstadienine, and others, and it is likely
that some of these or conversion products thereof also appear in
the fat and contribute to the taint.

The hypothesis that it is not only one compound which is responsible
for the boar taint is also confirmed by the fact that up till now,
many organoleptic investigations have been made, and that the corre-
lation to androstenone has on the whole been about 0.5.

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Thus, in three investigations, B. Malmfors (B. Malmfors & Ø. An-
dresen, Relationship between Boar Taint Intensity and Concentra-
tion of 5α-Androst-16-ene-3-one in Boar Peripheral Plasma and Back
Fat, Acta Agr. Scand., 25, 93 - 95, (1975) and B. Malmfors, K.

10    Lundström, I. Hansson, Interrelations between 5α-Androstenone,
Boar Taint, and Fatty Acid Composition, In. Prep. Dept. of Animal
Breeding, Agr. Coll. Uppsala) in three investigations finds correla-
tions of about 0.5 with large groups of Swedish Landrace, Yorkshire
and hybrids between Swedish Landrace, Yorkshire and Hampshire.

15    From Canada, Newell et al. (J.A. Newell et al., Influence of late
Castration and Diethylstilbestrol Implantation on Performance of
Boars and on Incidence of Boar Taint, Can. J. Anim. Sci., 53,
205, (1973)) report about a correlation of 0.53. Desmoulin (B. Des-
moulin, Recherches sur l'Evelage des Porcs, INRA-CNRZ, 78350

20    Jony-en-Josas, France, results presented at the 2nd meeting in
EAPP Working Group on "Production and Utilization of Meat from
Entire Male Animals, 18-19 Oct., 1977") finds correlations of 0.24 -
0.66 for the races Belgian Landrace and Pitain. At the Slagteriernes
Forskningsinstitut (The Danish Meat Research Institute) (Lis Buch-

25    ter, Sammenhæng mellem ornelugt og indhold af 5α-androstenon i
spæk, Slagteriernes Forskningsinstitut rapport 17/43, (1977)), 0.6
is found for Danish Landrace. The highest correlation ever disclosed
is 0.75 (Georg Fuchs, The Correlation Between 5α-Androst-16-ene-
3-one Content and the Sex Odour Intensity in Boar Fat, Swedish

30    J. Agric. Res., 1, 233 - 237, (1971)), but this was from a rather
limited number of animals, that is, 20, from which the results of
the three highest were lef out as it was believed that these could
not be distinguished organoleptically.

35    These correlations or, rather, lack of correlations, may be attributed
to three facts: The uncertainty of the organoleptic reference method,
the uncertainty of the androstenone determination, and the fact
that androstenone alone is not a particularly good indicator for the

phenomenon. It is probably most likely that what manifests itself is
a combination of all three influences.

The economic advantages in the meat production from boars has
always been so evident that many speculations have been made as
to how the boar taint could be avoided. It has been attempted to
perform castration at a later time when the main part of the meat
growth has taken place, or to administer diethylstilbestrol which
stops the hormone production, that is, "chemical castration" (J.A.
Newell et al., Influence of Late Castration and Diethylstilbestrol
Implantation on Performance of Boars and on Incidence of Boar Taint,
Can. J. Anim. Sci., 53, 205, (1973)). The average reduction of
the odour intensity took place with a factor of 2, but as castration
of grown-up pigs is a rather comprehensive operation with consider-
able risk of complications, and as, anyway, it is only partly effec-
tive, this is hardly an attractive solution.

It has also been presumed that there might be differences between
the races with respect to their tendency to show boar taint. As a
support for this presumption has been mentioned i.a. the fact that
English consumers apparently react in a considerably less negative
manner to boar meat than continental consumers (A. Landon, Meat
from Boars, Pig Farming, July 1977). Birgitta Malmfors (B. Malm-
fors & I. Hansson, Incidence of Boar Taint in Swedish Landrace
and Yorkshire Boars, Livest. Prod. Sci., 1, 411, (1974)) has tried
to investigate this and it has been found that the English race York-
shire has slightly less boar taint than Swedish Landrace. The dif-
ference is only just statistically significant and can hardly explain
the alleged acceptance of boar meat by the English consumers.

Another aspect which has been investigated is the possibility to
subdue the sex odour by selective breeding. This has been inves-
tigated by Wismer-Pedersen and P. Jonsson (P. Jonsson & J. Wismer-
Pedersen, Kønslugt hos orner af Dansk Landrace, Statens Husdyr-
brugsforsøg, Meddelelse nr. 110, 1976), but the material was not
statistically reliable. However, a slight positive correlation between
six odour and covering willingness was found, and this indicates
that if it is attempted to remove, through breeding, a parameter

like sex odour which is closely related to central hormonal processes, there is a risk that, at the same time, other (desired) properties such as covering willingness and the like will be disturbed.

5       Even if it were possible to subdue the sex odour through selective breeding, this would, however, take a long time, i.a. due to the badly estimated selection parameter, and as stated above, it is uncertain whether other (desired) properties can be maintained intact.

10     In the same manner as the chemical background has not been fully solved, the consumer response on boar meat showing boar taint is also highly varied. The above-mentioned investigations from England indicate that in England, it is by and large possible to market boar meat showing boar taint without reaction from the consumers. Other

15     comprehensive investigations from Holland (P. Walstra, Fattening of Young Boars: Quantification of Negative and Positive Aspects, Livestock Production Science, 1, 187 - 196, (1974)) arrive at a similar conclusion, i.e. that consumers generally hardly notice boar taint, but that, in spite of this, boars which show a strong boar taint

20     should anyway be sorted out in consideration of the few especially sensitive persons. Other investigations, for example a recent investigation at the Slagteriernes Forskningsinstitut (Lis Buchter & Asta Vimmerslev, Afprøvning af ornelugtens indflydelse på kvaliteten af svinekødsprodukter, Slagteriernes Forskningsinstitut, rapport

25     17/43-1 (1977)) showed that consumers clearly gave an inferior rating to boar meat showing boar taint.

Thus, the reaction on boar taint is highly varied which may possibly be due to the fact that considerable psychological moments enter

30     into the evaluation which is, therefore, difficult to quantificate, but even if it is few out of the consumers who are sentitive to the odour of boar meat, it would, in view of the general reputation of bacon products in general, not be desired to expose the consumers to boar taint.

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The economy in the production of boar meat has been investigated in great detail. Thus, in A. Landon, Meat from Boars, Pig Farming, July 1977, it is mentioned that the growth for boars is 712 g/day

versus 662 g/day for castrates, which means an about 10% larger
production from boars and, consequently, about 10% lower capital
investments. The utilization of the fodder is stated to be about 10%
better than for castrates, and the carcases have 9 - 20% less fat
layer than for castrates, which results in a higher classification.
The production loss in castration of male pigs is judged to be about
Dkr. 50 per pig, which means that in Denmark, with a production
of 5 million hogs, there is a total production loss of 250 million
Dkr./year. A similar amount is found by Walstra (P. Walstra,
Fattening of Young Boars: Quantification of Negative and Positive
Aspects, Livestock Production Science, 1, 187 - 196, (1974)) for
Dutch conditions, and for the EEC in total, the production loss has
been estimated at 3 billion Dkr./year.

Therefore, there is a great demand for an automatable standard
analysis method for the detection of boar taint which enables fast
and sufficiently reliable sorting out of carcases showing boar taint
in the production line at a slaughter house, as the procurement
and utilisation of such automatable standard analysis method would
make it possible, without any risk to the reputation of the bacon
production, to abstain from castration of male pigs and thereby to
enjoy the very great economical advantages connected therewith.
However, the existing methods for detecting boar taint are not suit-
able for this purpose:

Today, two categories of methods are used for detecting boar taint,
that is, direct methods (organoleptic methods) and indirect methods
(chromatographical, immunological and mass-spectrometrical methods).

The traditional organoleptic method may, e.g., be performed by
placing a slice of bacon on a glass Petri dish in an oven at 200°C
for 6 - 7 minutes, whereafter the slice is rated by an experienced
taste panel of 8 persons.

In recent years, some experimentation has been made with a variant
of this method, that is, the so-called handsealer or soldering bolt.
This consists of a soldering bolt with a specially designed point
which is thermostated to 150°C, and the method comprises first

placing the bolt on the fat for some seconds and thereafter placing
the bolt under one's nose. The handsealer method is faster than
the traditional method, although hardly quite as reliable, and has
spread widely and is even alleged to be useful for separation of
5    boars showing boar taint on the slaughtering line (P. Walstra, G.
Maleman, P.C. Moerman, Het Gebruick van De Handsealer in De
Slachtlijn Ter Vaststilling van Beregeur, Tijdschr. Diergeneesk.
dul / 02, afl. 15, p. 913 (1977)), but the exactitude must be pre-
sumed to be too low.

10

The organoleptic reference method is clearly subject to a consider-
able variation, but when performed correctly using large taste pa-
nels, with consideration to psychology, adaptation, individual varia-
tion and the like, it constitutes a reasonably good tool. However,
15   the method will hardly be useful for the separation on the slaughter-
ing line as it is too laborious to be economical.

The other known methods all detect androstenone and all require
an extraction, fractionation and purification. This separation proce-
20   dure may be performed in various manners, but as a typical separa-
tion procedure may be mentioned (W.D. Hubbard et al., Comparison
of Various Methods for the Extraction of Total Lipids, Fatty Acids,
Cholesterol, and other Sterols from Food Products, J. of AOCS,
54, p. 81 (1977)): extraction with chloroform/methanol, homogenisa-
25   tion in a blender, filtration, washing with water, phase separation,
washing of water phase and evaporation of solvent.

Another example (Ø. Andresen, A Radioimmunoassay for 5α-Androst-
16-ene-3-one in Porcine Adipose Tissue, Acta Endocrinologica, 79,
30   619 - 624 (1975)) is: fat tissue is homogenised in absolute ethanol
and is thereafter centrifuged, the supernatant is separated and
cooled down with dry ice/acetone, then centrifugation is again per-
formed and the supernatant is separated, whereafter the solvent
is carefully evaporated.

35

It is evident that sample preparation procedures of this character
are not exactly suitable in an automated, fast detection method.

Among chromatographic methods, thin layer chromatography (R. Claus, B. Hoffman, H. Karg, Determination of 5α-Androst-16-ene-3-one, a Boar Taint Steroid in Pigs, with Reference to Relationships to Testosteron, J. Anim. Sc., $\underline{33}$, p. 1293 (1971)), gas chromatography (J. Wismer-Pedersen, Landøkonomisk Forsøgslaboratorium, Efterårsmøde, p. 136 (1968)) as well as high pressure liquid chromatography and gas/liquid chromatography (O.B. Gower, 16-Unsaturated $C_{19}$ Steroids. A Review of Their Chemistry, Biochemistry, and Possible Physiological Role, J. Steroid Biochemistry, $\underline{3}$, 45 (1972)) have been used. All these methods have now been given up because of failing sensitivity and have been replaced by radio-immunoassay. All teams of scientists in Europe (about 5) working with determination of androstenone use radioimmunoassay (RIA).

Briefly, radioimmunoassay comprises coupling the androstenone, subsequent to separation and purification, to a radioactively labelled androstenone-antibody. After separation of the antigen/antibody complex, the remaining radioactivity is determined as a measure of the androstenone concentration.

The method is sensitive and reasonably reliable (interlaborary deviations of up to a factor of 2 have, however, been reported), but it is a pronounced laboratory method which additionally requires isotope laboratory.

Another variant of the immunological method, in which variant the necessity of an isotope laboratory can be avoided, is ELISA, or enzyme-coupled immunosorbent assay. Originally, the method was developed and instrumented for detection of hepatitis virus in blood banks, but it has also been used, e.g., for the detection of antibodies against trichinae in pigs in slaughterhouses (Ruitenberg et al., Application of ELISA for the Serodiagnosis of T. Spirales Infections in Pigs under Slaughterhouse Conditions, Proc. IIIrd Int. Congress of Parasitology, München, 1203 (1974)) and would be adaptable to androstenone determination in slaugtherhouses. However, the method uses various expensive chemicals and does not immediately seem to be especially well suited for use under slaughter-

house conditions, and it requires a complete sample preparation with weighing out of fat tissue, extraction, separation and purification.

5     The mass spectrometrical methods show the same disadvantages as are mentioned above in connection with chromatographical methods, as the separation step in the mass spectrometrical methods is performed by gas chromatography.

10     The present invention provides a method for detecting boar taint in individual carcases of uncastrated boars or parts thereof, which method is suitable for on-line utilisation in slaughterhouses or other industries treating the individual boar carcases or parts thereof, and the method is characterised in that IR spectrophotometrical transmission data are determined for the individual carcase or part,

15     and spectral data thus registered are compared with corresponding data having a statistical relationship to boar taint.

The IR spectrophotometrical transmission data having a statistical relationship to boar taint may be found empirically or through a

20     combination of theoretical considerations and empirical experiments, using, for this purpose, well-known statistical methods for assessing the relationship between boar taint and the spectral data contemplated for use as a basis for the correlation determination. These assessments can be performed by the skilled art worker on the basis of

25     the inventive recognition of the fact that IR spectrophotometrical transmission data do exist which have a statistical correlation with boar taint, and that such spectral data may be used in a simple, automatable and convincing manner as a basis for a reliable sorting according to organoleptic criteria.

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When IR transmission measurement is performed on a sample from the individual boar carcase or part, this sample may be any sample which has been directly taken from the individual carcase or part or any preparation or derivative of the sample from the individual

35     carcase or part suitable for the determination in question, for example an extract of fat tissue from the individual boar or a vapour phase provided by evaporation of fat from the individual boar carcase.

In contradistinction to the above-mentioned known methods which have been experimentally used for the determination of boar taint in slaughterhouses, IR transmission analyses are advantageous in that they may be performed fast and exactly in suitable apparatus, and when they use samples from the individual boar carcase or part, they may be adapted in such a manner that the sample preparation becomes reasonable for the purpose. A special advantage of suitable determinations for the purpose of the invention is that it is not necessary to perform any weighing out of the sample in cases where a standardised sample preparation technique is combined with transmission measurements in a cuvette with a predetermined light path, or, which is especially suitable, in cases where the statistical correlation to boar taint is related to the ratio between transmission or absorption at two distinct wave lengths in the IR spectrum such as is illustrated in Example 1, as in these cases, the size or weight of the sample is not significant to the results, except that the samples should be of a order of size which is suitable for the determination in question.

The sample withdrawal in the process of the invention may be performed with various levels of automation. For example, at the start of the slaughtery line, a portion of fat tissue may be cut out which, subsequent to coding in the number of the pig, is transported, for example, on a cup elevator/conveyor, to an analysis automate where the further sample preparation consists of heating of the sample to fluid consistency and aspiration of the fluid fat into the measuring cuvette. In this connection, it may be suitable to perform a filtration or centrifugation of the fluid fat. Furthermore, it is suitable that the flow system in the analysis automate is cleaned automatically, for example with detergent/deionized water.

If the sample from the carcase is evaporated, the sample withdrawal may simply be performed by aspiration which may be performed in an almost fully automated manner. Thus, at the classification station, such burning-sample-withdrawal may be performed either by means of a specific probe or a function built together with the conductivity probe already in use.

The further analysis of the combustion gasses should be performed
in a very sensitive system, and for this purpose, IR laser systems
are attractive. For example, an IR LOS system (Laser Optoacoustic
Spectroscopy) may, in a couple of minutes, analyse a mixture of 10
5       gasses with a sensitivity which, in practice, is about 1 ppb (L.B.
Kreutzer, Laser Optoacoustic Spectroscopy. A New Technique of
Gas Analysis, Analytical Chemistry, 46, 240A, (1974); and L.B.
Kreutzer, N.D. Kenyon, C.K.N. Patel, Air Pollution: Sensitive De-
tection of Ten Gases by Carbon Monoxide and Carbon Dioxide Lasers,
10      Science, 177, page 347, (1972)) and with a theoretical detection
limit of $10^{-3}$ (L.B. Kreutzer, Ultralon Gas Concentration Infrared
Absorption Spectroscopy, J. of Applied Physics, 42, 2934, (1971)).
Such systems are robust and suitable for industrial process control
(L.B. Kreutzer, Laser Optoacoustic Spectroscopy. A New Technique
15      of Gas Analysis, loc. cit.).

According to the invention, a sufficiently reliable determination may
be obtained on the basis of a single IR spectral parameter. Thus,
the IR absorption in the wave length range of 1275 - 1335 $cm^{-1}$,
20      especially 1300 - 1310 $cm^{-1}$, has shown a correlation coefficient of
0.6 - 0.8 to boar taint with a standard deviation of 1/2 taint rating
according to a series from -5 (best taint) to +5 (worst taint; the
most pronounced boar taint). In Example 1, an especially suitable
parameter is exemplified, that is, the relation between absorption
25      at two different wave lengths in the IR spectrum, especially in the
same range of 1275 - 1325 $cm^{-1}$. A still higher correlation between
the data determined in the process of the invention and the organo-
leptic data may be obtained by determining one or more further
parameters with statistical correlation to boar taint and using the
30      correlation between the determination of the further parameter or
parameters for the individual boar carcase or part and corresponding
data having a statistical relationship to boar taint as an additional
parameter or additional parameters in a statistical analysis, for ex-
ample performed by multiple correlation or discriminant analysis in
35      the detection of whether the boar carcase or part shows boar taint.
Thus, for example, the concentration of androstenone, hexanal and
skatol in the fat of the boar carcase, or especially the concentration
of unsaturated fatty acids in the fat of the boar carcase, for example

determined as refractive index or iodine number, are parameters having a statistical correlation to the odour image (the higher concentration, the higher likelihood of boar taint), and which advantageously may be incorporated in a statistical analysis, e.g. multiple correlation, to obtain increased correlation coefficients. Example 2 illustrates the increase of the correlation coefficient obtained when an IR determination on the melted fat is combined with the chemical determination of the iodine number as an expression of the degree of unsaturation of the fatty acids present in the fat.

In addition to iodine number determination or refractive index determination, a measure of unsaturation may also suitably be obtained by direct IR transmission measurement, e.g. a measurement at about $3000 \text{ cm}^{-1}$, where it has been found that there is a high correlation to the iodine number such as appears from the table below showing iodine number in relation to IR transmission measurement for 5 boar samples (measured with a Perkin-Elmer IR spectrophotometer):

## Table

| Iodine number g/100 g | IR (transmission at $3004 \text{ cm}^{-1}$ divided by transmission at $2992 \text{ cm}^{-1}$) |
|---|---|
| 61.4 | 0.709 |
| 63.4 | 0.686 |
| 62.5 | 0.693 |
| 64.1 | 0.680 |
| 59.3 | 0.725 |

The correlation coefficient is 0.99.

This means that a particularly high correlation may be obtained when a measurement in the range of $1275 - 1325 \text{ cm}^{-1}$, either of the absorption at a single wave length in this range or of the ratio between

the absorptions at two different wave lengths in this range, is combined with a measurement at about 3000 $cm^{-1}$ which serves to establish a measure of the iodine number in the statistical analysis, for example the multiple correlation with the discriminant analysis.

5      In addition, the statistical analysis may include the result of a measurement at other wave lengths giving an improved correlation to boar taint.

10     Example 1.

From each of a series of 10 pieces of streaky bacon from a sow and 9 boars, respectively, fat was extracted in the following manner: 45 g of meat sample were extracted with 50 ml of perchloroethylene

15     for 2 minutes in a Foss-Let reactor (a closed steel container in which the sample together with perchloroethylene is subjected partly to shaking and partly to working with a reciprocating piston), and the extract containing the major part of the fat content of the sample was filtered through kieselguhr and was thereafter ready for the

20     following investigations.

The filtrates from the 10 samples were transferred to the cuvette in a Perkin-Elmer Infrared Spectrophotometer 580, by means of which transmittances were measured in frequences around the peak at about

25     1280 $cm^{-1}$ with a reference plateau at about 1300 $cm^{-1}$. Between the measurements, the cuvette was first flushed with perchloroethylene, thereafter twice with the next sample to be measured, and after a third thorough flushing, the measurement was performed.

30     On samples from each piece, organoleptic determination with a flavour panel of 8 persons was also performed. The results appear from the table below:

## Table I

Ratio peak wave length/reference wave length for sow meat and boar meat, respectively, at various taint ratings according to a series from 0 (best taint) to 5 (worst taint).

| $\lambda^1/\lambda^2$ | 1300/1280 | 1300/1275 | 1300/1270 | 1295/1280 | 1295/1275 |
|---|---|---|---|---|---|
| Sow | 1.1235 | 1.1463 | 1.1701 | 1.1111 | 1.1359 |
| 0.0 | 1.1247 | 1.1531 | 1.1777 | 1.1189 | 1.1446 |
| 0.38 | 1.1173 | 1.1415 | 1.1643 | 1.1057 | 1.1316 |
| 0.38 | 1.1210 | 1.1484 | 1.1722 | 1.1111 | 1.1359 |
| 0.50 | 1.1208 | 1.1457 | 1.1694 | 1.1129 | 1.1356 |
| 0.75 | 1.1171 | 1.1420 | 1.1656 | 1.1091 | 1.1362 |
| 1.62 | 1.1208 | 1.1460 | 1.1698 | 1.1131 | 1.1379 |
| 2.12 | 1.1171 | 1.1392 | 1.1620 | 1.1075 | 1.1292 |
| 3.38 | 1.1090 | 1.1346 | 1.1569 | 1.1015 | 1.1248 |
| 3.75 | 1.1054 | 1.1259 | 1.1472 | 1.0941 | 1.1167 |
| Correlation co-efficient | 0.90 | 0.88 | 0.88 | 0.81 | 0.85 |

| $\lambda^1/\lambda^2$ | 1295/1270 | 1290/1280 | 1290/1275 | 1290/1270 | 1300/1285 |
|---|---|---|---|---|---|
| Sow | 1.1618 | 1.0932 | 1.1197 | 1.1408 | 1.0658 |
| 0.0 | 1.1692 | 1.1002 | 1.1282 | 1.1524 | 1.0661 |
| 0.38 | 1.1540 | 1.0863 | 1.1139 | 1.1363 | 1.0639 |
| 0.38 | 1.1615 | 1.0911 | 1.1176 | 1.1408 | 1.0682 |
| 0.50 | 1.1612 | 1.0930 | 1.1174 | 1.1405 | 1.0642 |
| 0.75 | 1.1598 | 1.0934 | 1.1199 | 1.1435 | 1.0644 |
| 1.62 | 1.1615 | 1.0933 | 1.1199 | 1.1408 | 1.0665 |
| 2.12 | 1.1540 | 1.0921 | 1.1135 | 1.1357 | 1.0622 |
| 3.38 | 1.1468 | 1.0846 | 1.1075 | 1.1314 | 1.0571 |
| 3.75 | 1.1399 | 1.0818 | 1.1018 | 1.1248 | 1.0555 |
| Correlation coef-ficient | 0.87 | 0.72 | 0.84 | 0.82 | 0.88 |

(Table I continued)

| $\lambda^1/\lambda^2$ | 1305/1280 | 1305/1285 | 1310/1280 | 1310/1285 |
|---|---|---|---|---|
| Sow | 1.1403 | 1.0866 | 1.1640 | 1.1071 |
| 0.0 | 1.1502 | 1.0897 | 1.1728 | 1.1113 |
| 0.38 | 1.1338 | 1.0801 | 1.1568 | 1.1040 |
| 0.38 | 1.1389 | 1.0870 | 1.1647 | 1.1075 |
| 0.50 | 1.1431 | 1.0849 | 1.1647 | 1.1077 |
| 0.75 | 1.1349 | 1.0813 | 1.1567 | 1.1021 |
| 1.62 | 1.1440 | 1.0875 | 1.1680 | 1.1061 |
| 2.12 | 1.1346 | 1.0804 | 1.1555 | 1.1005 |
| 3.38 | 1.1316 | 1.0789 | 1.1498 | 1.0966 |
| 3.75 | 1.1215 | 1.0729 | 1.1415 | 1.0920 |
| Correlation coefficient | 0.74 | 0.77 | 0.80 | 0.90 |

It will be noted that the maximum correlation coefficient is obtained
at the ratios 1300/1280 and 1310/1285, but that the other correlation
coefficients are also quite satisfactory. When using this system, it
will be suitable to sort out carcases having a taint rating of 2 or
5    worse, which will correspond to a ratio between peak wave length
absorption and reference wave length absorption of about 1.12.

Thereafter, 7 chop pieces were analysed by determination of the
absorption at 1310 and 1285 $cm^{-1}$, respectively, and determination
10    of the ratio between the absorptions. The taint ratings varied even-
ly from 0.12 to 3.38 when determined according to a series from 0
(best taint) to 5 (worst taint; most pronounced boar taint). The
correlation coefficient was found to be 0.88.

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Example 2.

On 10 samples of fat melted from boars, organoleptic taint determi-
nation was performed with a flavour panel of 8 persons. The samples
20    were evaluated according to a series with ratings from +5 to -5.
The negative part of the series indicates increasingly bad taint.
The results appear from the table below in the column "Organoleptic
taint rating", as average of the evaluation by the 8 persons.

25–    The fat samples were melted from a minced sample withdrawn from
the individual boar carcase. The minced sample was placed in a glass
beaker on a sand bath, the temperature of the sand bath being
such that the sample temperature was between 50 and 60°C. As soon
as a reasonable portion of fat had been melted off, the fat was de-
30    canted, and the melted fat was kept in refrigerator in plastic beakers,
as it had been found that when standing at room temperature, the
samples were subject to changes, presumably by going rancid, and
gave other IR results. IR spectrophotometric determinations were
performed on fluid fat from the 10 samples. In the table below, the
35    results are stated as the ratio between the transmittance at 1300
$cm^{-1}$ and the transmittance at 1275 $cm^{-1}$.

The apparatus used is a modified "Milko-Scan" 203, which is an IR
spectrophotometer especially developed for measurement of fat, pro-
tein and lactose in milk, and which is described in detail in "The
Analysis of Milk by Infrared Absorption", A Thesis submitted for
the Degree of Batchelor of Philosophy at the University of York,
by John Shields, November 1975. For the present purpose, the ap-
paratus was modified in the following manner: 4 of the 6 optical
filters of the apparatus had been changed in order to measure the
wave length ratios at $1300$ $cm^{-1}/1275$ $cm^{-1}$ and $1300$ $cm^{-1}/1235$ $cm^{-1}$,
these ratios being directly read out and simultaneously printed on
a connected printer. The cuvette and the interior of the apparatus
were thermostated to $50^{o}C$ to ensure that the fat was kept fluid in
the cuvette. The otherwise built-in homogeniser of the apparatus,
used for milk, had been removed, and the fat was manually injected
directly into the cuvette. In comparison with the normal version,
the sensitivity of the apparatus had been increased through higher
amplification in the electrical circuit, which necessitated measurement
on a standard to enable correction for apparatus drift. As a standard,
pure commercial lard was used.

In the measurement, the cuvette (cuvette path 37 µm) was first
thoroughly flushed with the sample, whereafter three 10-fold deter-
minations were performed on the sample, new sample material being
flushed through the cuvette prior to each 10-fold determination.
Before and after the sample, 10-fold determination on the standard
was performed, and the result for the sample was corrected with
the average of the standard measurements.

Column 3 in the following table shows the taint rating obtained when
linear correlation between organoleptically determined taint and IR
measurement is performed and the taint is read out by means of
the resulting correlation equation.

Column 4 of the table states the iodine number, which is a measure
of the degree of unsaturation, determined by the chemical standard
method. The unit is g of iodine per 100 g of fat. Finally, column 5
states the taint rating obtained when multiple regression analysis

is performed between organoleptically determined taint, IR-measured ratio and iodine number.

As will be noted from the table and the calculations of correlation coefficients stated below the table, the use of a multiple correlation results in a considerable increase of the correlation coefficient.

It is possible to use other statistical methods than regression and multiple regression analysis in the treatment of the data material. For example, the data for the 10 samples have been treated in a discriminant analysis. By this, it was possible to sort the samples perfectly into three groups with the limits taint > -1, -1 > taint > -2.5 and taint < -2.5.

## Table II

Melted fat measured on modified Milko-Scan 203

| Readout 1300/1275 | Organo-leptic taint rating | Taint determined via IR measure-ment (linear regression) | Iodine number g/100 g | Taint determined via IR measure-ment and iodine number (multiple linear regression) |
|---|---|---|---|---|
| 0.27 | 0.25 | -0.75 | 70.95 | -0.72 |
| 0.25 | 0.00 | -1.05 | 70.77 | -1.10 |
| 0.31 | -0.50 | -0.13 | 73.77 | -0.57 |
| 0.22 | -1,00 | -1.51 | 64.78 | -0.28 |
| 0.21 | -1.50 | -1.66 | 67.00 | -1.02 |
| 0.17 | -1.75 | -2.27 | 65.50 | -1.49 |
| 0.17 | -1.88 | -2.27 | 70.30 | -2.64 |
| 0.16 | -2.62 | -2.43 | 70.05 | -2.74 |
| 0.25 | -3.12 | -1.05 | 75.00 | -2.12 |
| 0.14 | -3.50 | -2.73 | 70.20 | -3.24 |

| | | Organoleptic determi-nation versus IR measurement | Organoleptic determi-nation versus IR measurement and iod-ine number determina-tion |
|---|---|---|---|
| Correlation coefficient | R | 0.68 | 0.85 |
| Index of determination | $R^{12}$ | 0.46 | 0.73 |
| Adjusted index of determ. | $R^{12}$ | 0.39 | 0.65 |

$$R^{12} = \frac{N-1}{N-P} \times R^2 - \frac{P-1}{N-P}$$

N = number of measurements

P = number of independent variables

Claims.

1. A method for detecting boar taint in individual carcases of un-
castrated boars or parts thereof,
c h a r a c t e r i z e d  by determining IR-spectrophotometrical
transmission data for the individual carcase or part and comparing
spectral data thus registered with corresponding data having a sta-
tistical relationship to boar taint.

2. A method as claimed in claim 1,
c h a r a c t e r i z e d  in that the sample on which the deter-
mination is performed is a fat sample from the carcase or part in
question.

3. A method as claimed in claim 1 or 2,
c h a r a c t e r i z e d  in that the IR parameter on which the
comparison is based is the ratio between the absorption at two dif-
ferent wave lengths in the IR spectrum.

4. A method as claimed in claim 3,
c h a r a c t e r i z e d  in that the ratio at which the carcase or
part is sorted as showing boar taint is a ratio which is statistically
equivalent with a taint rating of -2 in a series from -5 (worst taint)
to +5 (best taint).

5. A method as claimed in any of the preceding claims,
c h a r a c t e r i z e d  in that one or more further parameters
with statistical correlation to boar taint is/are determined, and that
the correlation between the determination for the additional parameter
or parameters for the individual boar carcase or part and correspond-
ing data having a statistical relationship to boar taint is used as
a further parameter or further parameters in a statistical analysis
for detecting whether the boar carcase or part shows boar taint.

6. A method as claimed in claim 5,
c h a r a c t e r i z e d  in that the additional parameter determined
is the concentration of unsaturated fatty acids in the fat of the
carcases or parts.

7. A method as claimed in claim 6,
c h a r a c t e r i z e d   in that the concentration of unsaturated
fatty acids in the fat of the carcases or parts is determined as re-
fractive index or by IR transmission measurement.

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# INTERNATIONAL SEARCH REPORT

## I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) 5

According to International Patent Classification (IPC) or to both National Classification and IPC2

G 01 N 33/12, G 01 N 21/00

## II. FIELDS SEARCHED

### Minimum Documentation Searched 4

| Classification System | Classification Symbols |
|---|---|
| IPC 2 | A 23 L 1/31; G 01 N 21/00, 21/02, 33/12 |
| US Cl | 426:248 |

### Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched 5

SE, NO, DK, FI classes as above

## III. DOCUMENTS CONSIDERED TO BE RELEVANT 14

| Category* | Citation of Document, 16 with indication, where appropriate, of the relevant passages 17 | Relevant to Claim No. 18 |
|---|---|---|
| X | DE, A, 2 728 717 published 1979, January 25, H Barten | |
| A | SE, B, 345 740 published 1972, June 5, N G Menshikov | |
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| A | DE, A, 2 912 848 published 1979, October 4, J H Grobbelaar | |
| A | E Andersen "Industriel Levnedsmiddel-konservering, Bind 1, General del", Köbenhavn 1965, p. 138-144, 158-159, 180-181, 194-196 | |

* Special categories of cited documents: 15

"A" document defining the general state of the art

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"P" document published prior to the international filing date but on or after the priority date claimed

"T" later document published on or after the international filing date or priority date and not in conflict with the application, but cited to understand the principle or theory underlying the invention

"X" document of particular relevance

## IV. CERTIFICATION

| Date of the Actual Completion of the International Search 2 | Date of Mailing of this International Search Report 2 |
|---|---|
| 1980-06-30 | 1980-08-12 |

| International Searching Authority 1 | Signature of Authorized Officer 10 |
|---|---|
| Swedish Patent Office | Agneta Änggård |